## Matter, Structure and Properties of

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Matter is the substance that makes up all objects in the observable universe. Although all matter is composed of the same basic or fundamental particles, it may take on several forms, all of which exhibit different properties. All forms of matter share some basic properties such as gravitation (the force that attracts objects to one another) and inertia (the tendency of a body to resist any change in its motion or lack of motion). Mass, which is commonly identified as the amount of matter an object contains, is technically a measure of its inertia. According to Einstein's special theory of relativity, matter is also a form of energy. That is, matter can be converted into energy and vice versa.

### Basic Structure of Matter

All matter is composed of particles called atoms, which are themselves made up of smaller particles. At the center of an atom is a dense nucleus consisting of positively charged protons and electrically neutral neutrons. The nucleus accounts for more than 99.9 percent of the mass of an atom. It is held together by an attractive force called the strong nuclear force, which overcomes the tendency of the similarly charged protons to repel each other. Protons and neutrons are made up of still smaller particles called quarks.

The atomic number of an atom is the number of protons in its nucleus. All atoms with the same atomic number have almost identical chemical properties and are thus atoms of the same element. For example, all atoms that have an atomic number of one are hydrogen atoms. However, not all atoms of a given element have the same number of neutrons in their nuclei. Atoms that have the same atomic number but a different number of neutrons are called isotopes of that element. Hydrogen, for example, has three isotopes--each with one proton, but with one, two, or three neutrons. Isotopes share chemical properties, but they differ in mass. Some isotopes are unstable, or radioactive, releasing particles and energy as they attempt to reach a stable state.

Surrounding the nucleus, at a great distance on the atomic scale, is a cloud of negatively charged particles called electrons that have almost no mass. Because opposite electrical charges attract, the electrons are bound to the nucleus. In neutral atoms, the number of electrons is equal to the number of protons, but an atom may have unequal numbers of electrons and protons. Such an atom, called an ion, has an overall positive or negative charge, depending upon whether it has more protons or more electrons. Electrons are distributed about the nucleus in a complex manner, and the arrangement of the orbiting electrons determines the size of the atom and how it interacts with other atoms and particles. Atoms may combine with one another by transferring or sharing electrons, forming larger particles called molecules.

### States of Matter

Although all matter is made up of the same particles, it exists in several states, the most familiar states being liquid, solid, and gaseous. Each of these states can be subdivided into smaller groups according to the properties it exhibits. For example, solids may be classified as crystals, which have an orderly repeating internal structure (such as diamond or quartz), or amorphous solids, which have a more chaotic internal structure (such as glass or opal).

In the solid state, matter is generally hard and rigid, so a solid could be defined as an object that keeps its shape if not disturbed. However, not all solids are equally rigid. Many solids are classified according to how predictable or regular their structure is. A solid is said to have long-range order if the positions of all its atoms can be accurately predicted based on the position of one atom and its neighbors. If only the positions of nearby atoms can be predicted, the solid is said to have short-range order. Solids with long-range order are typically harder than solids with short-range order.

Matter in the liquid state takes the shape of any container in which it is placed, but it takes up the same amount of space in any container. Liquids have the high density of solids but lack their rigid, ordered structure. Many liquids such as water have short-range order. The liquid state is sometimes described as a transition between the solid and gaseous states. However, for most forms of matter, the distinctions among solid, liquid, and gaseous states are always clear.

The gaseous state is marked by many molecules moving randomly and colliding with each other. A gas will expand to fill a container, and its properties, such as pressure and temperature, will depend on the volume of the container but not on its shape. These properties--pressure, temperature, and volume--are linked in a gas, and changing one will affect the others.

### Key Terms

mass

amount of matter that causes an object to have weight when it is in an area influenced by gravity; commonly measured in kilograms

density

amount of mass (matter that causes an object to have weight) in a unit of volume

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